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EXTENSION OF PACK METHOD FOR COMPRESSIVE TESTS

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SUMMARY

The pack method for determining compressive stress-strain graphs described in NACA Report No. 649 has been modified to extend its application to thinner gages and stronger materials. The principal modifications consisted in the provision of additional support against instability by cementing the specimens of the pack together with fused shellac and the provision of special clamps that hold the specimens in the pack together while the test is in progress. The shellac was found to increase the buckling load of the pack without any appreciable effect on the compressive stress-strain graph of the material. The extended pack method described in this note has made possible the application of stresses in excess of 220 kips per square inch to sheet material having a thickness of only 0.02 inch.

INTRODUCTION

The pack method described in reference 1 has permitted the application of compressive stresses up to 60 kips per square inch to packs composed of 13, 7, and 5 specimens of 0.032-, 0.064-, and 0.081-inch aluminum-alloy sheet, respectively, and of stresses up to 180 kips per square inch to packs, composed of 5 specimens of 0.05-inch steel sheet, without failure by instability. Extension of this method to still thinner gages and higher stresses than heretofore obtained was urgently needed to test certain sheet material for aircraft submitted to the National Bureau of Standards by the Bureau of Aeronautics, Navy Department.

A number of modifications of the pack method were accordingly considered. Successful results were obtained with the technique described in this report, which was developed with the support of the Bureau of Aeronautics, Navy Department, and the National Advisory Committee for Aeronautics. All details of the procedure are given because

time has not permitted an exploration of limitations of the technique.

The testing procedure is an extension of the method described in reference 1 for making pack compressive tests and involves the use of additional means of support which increase the lateral stability of the pack so that it will not fail before the yield strength of the material is reached.

One support is provided by cementing the specimens of the pack together with fused shellac. A further support is provided by clamps that hold the specimens in the pack together while the test is in progress.

The author of this paper acknowledges the assistance and advice received from other members of the engineering mechanics section of the National Bureau of Standards. In particular, he expresses his appreciation to J. A. Miller who assisted in making the tests and to Walter Ramberg and A. E. McPherson who suggested the use of shellac for a cementing medium. He also wishes to acknowledge the valuable advice of C. C. Hartman of the Chemistry Division in connection with the development of the technique for cementing the specimens together with fused shellac.

MACHINING PROCEDURE

The blanks for the specimens were sheared about 0.05 inch longer and wider than the finished dimensions after surface grinding. The middle specimen of the pack was finished to a length of 3.56 inches and a width of 0.735 inch. The finished dimensions of the supporting specimens were 3.62 by 0.715 inch. After the specimens were cemented together as described in the next session, the pack, G (fig. 1), was machined to a length of 3.50 inches.

CEMENTING PROCEDURE

The sheet faces of the specimens in each pack were cemented together by means of a layer of fused shellac, which did not exceed 0.001 inch in thickness, by the following procedure:

The specimens were inspected for burs, scraped where necessary, cleaned, and finally rinsed by dipping in denatured alcohol. The order and the position of the specimens in the pack were determined at this time, and the specimens were placed in the predetermined position in the rack (fig. 2). Each specimen was then coated with shellac applied by dipping into a shellac varnish. The varnish consisted of 4 pounds of orange flake shellac conforming to type A of Federal Specification TT-S-271 (April 29, 1940) cut in 1 gallon of denatured alcohol (100 gallons of 190 proof ethyl alcohol and 5 gallons of approved wood alcohol). The specimens were placed in the rack to dry (fig. 2) with the lower edges resting on blotting paper, B, and the upper edges against nails, N. Alternate specimens were placed in the rack inverted from their position in the pack so that any thickening of the layer of shellac toward the bottom would be compensated for when the specimens were assembled in the pack.

After the specimens were dried for about 14 hours in air at room temperature, the excess shellac and the dust particles were removed with a scraper and the pack was assembled in a jig (fig. 3) designed to hold two packs. The supporting specimens were restrained against movement in the direction of their length by the brass collars, L, about the steel studs, S, and against movement in the direction of their width by the fixed stops, X, and by the adjustable stops, V. The short middle specimen was held against movement in the direction of its length by the sides of the fixed stops, X, and against movement in the direction of its width by the fixed stops, Z. The specimens were held together by the jig clamp, D, shown disassembled in the lower part of figure 3. The edges of the specimens in a pack are shown at G' under the movable jaw, M, of the clamp. The fixed stops, Z, for the middle specimen were held in position by machine screws, with washers, F, in slots, W, which were machined 2.10 inches apart; the fixed stops for the supporting specimens, X, were similarly held in slots, Y, spaced 3.58 inches apart. Two slots, O, 1/2 inch wide and 1/2 inch deep, were machined $2\frac{1}{2}$ inches apart across the top face of the block so that the end clamps, E, could be attached before the shellac was fused.

The shellac was fused by heating in an oven held at a temperature of 64° C ±3° C. At intervals, while the shellac was being fused, the clamps were tightened when necessary. After the pack was heated for not less than

7 hours, it was cooled in air in the jig. The jig clamp, D (fig. 3), was then loosened, and the pack, with end clamps attached, was machined to length.

END CLAMPS AND AUXILIARY CLAMPS

Clamps, E (figs. 1 and 3), were attached within 0.02 inch of the ends of the pack in order to keep the specimens from spreading apart. Each of these clamps was made from two pieces of $1\frac{7}{16}$- by 1/2- by 1/2-inch cold-rolled steel joined together by two size 10-32 machine screws, spaced 1 inch on centers.

As an additional precaution against spreading, two auxiliary clamps, A, shown in figures 1 and 4, were attached about 7/8 inch from each end of the pack before it was placed in the testing machine. Each auxiliary clamp consisted of two brass channel-shaped pieces, C (fig. 4), which were held together by two machine screws, H. The depth of the channel pieces was $1\frac{1}{8}$ inches, the flange width was 1/2 inch, the flange thickness was 3/16 inch, and the web thickness was 1/4 inch. Only the sheet faces of the outside specimens of the pack were in contact with the inside faces of the auxiliary clamps.

During the test, the auxiliary clamps were prevented from slipping along the pack by slightly imbedding the conical points, Q (fig. 4), in each of the outside sheet faces of the pack. These screws were threaded about 9/32 inch apart in each of the webs of the clamp. They were tightened after the clamps had been tightened in their proper location by the screws, H. Three conical holes, T, were machined 9/32 inch apart in the outer face of each web, so that pins could be used for external support.

TRANSVERSE SUPPORT

The transverse support was supplied by 30 steel pins, P (fig. 1), on each side of the pack. This support was the same for these tests as the transverse support described in reference 1 with the exception that the pins which were used for the external support of the auxiliary clamps were about $1\frac{3}{4}$ inches long instead of about 2 inches.

TESTING PROCEDURE

The testing procedure was the same as described in reference 1, with the exceptions that the end clamps were not removed and that the pins were assembled according to the following sequence: The pins in rows 2 and 9 (opposite the auxiliary clamps) were first located and tightened. The pins in the other rows were then located and tightened in any convenient sequence.

DISCUSSION

Figure 5 shows a stress-strain graph obtained by the foregoing method for a pack of 31 specimens taken in the transverse direction from 0.02-inch-thick sheet. It is seen that the method makes possible the application of stresses in excess of 220 kips per square inch to sheet material of this thickness.

It must be emphasized that the limitations of this technique have not been thoroughly explored. One test was made, however, to determine whether the additional support provided by the clamps, without cementing the specimens of the pack together, was adequate to prevent buckling before the yield strength was reached. Two packs, C1L and C2L, each composed of 31 specimens, cut in the same direction from a sheet of 0.02-inch-thick material, were tested in compression with the results shown in figure 6. Pack C2L, not cemented, failed suddenly at a stress of 72.2 kips per square inch; whereas pack C1L, cemented with shellac, was loaded to a stress of 95.5 kips per square inch without failing. The test indicated that the support provided by cementing the specimens together with fused shellac increased materially the stress at which the packs failed through instability. The results also indicated that the fused shellac did not significantly affect the shape of the compressive stress-strain graph.

Tests were also made to determine the critical stress of cemented packs with end clamps attached but without auxiliary clamps or external lateral support. In one of these tests a pack sustained a stress of 213.6 kips per square inch before it buckled. This result suggested the possibility of omitting the pins and the auxiliary clamps. In other tests of this kind, however, the buckling stresses were much lower.

Even when all the supports were employed, some packs buckled before the yield strength of the material was reached. Several of these failures resulted from a poor shellac bond that seemed to be associated with a mat finish of the surface of the material. In others the shellac bond near the end of the pack appeared to have been loosened by contact with sodium-carbonate solution that had inadvertently been used as a coolant while grinding the ends of the pack. Finally, there was one case in which the buckling at a low stress was attributed to failure to follow meticulously the testing procedure. In a preponderance of instances, however, the methods of support employed in these tests were sufficient to prevent buckling until the yield strength of the material was reached.

Although this method seems satisfactory for many problems in structural research, it will need to be simplified before it can be used satisfactorily for inspection testing. The details of the method are given in the hope that their publication will expedite the development of a relatively simple compressive test for thin high-strength materials.

National Bureau of Standards,
Washington, D. C., August 1940.

REFERENCE

1. Aitchison, C. S., and Tuckerman, L. B.: The "Pack" Method for Compressive Tests of Thin Specimens of Materials used in Thin-Wall Structures. Rep. No. 649, NACA, 1939.

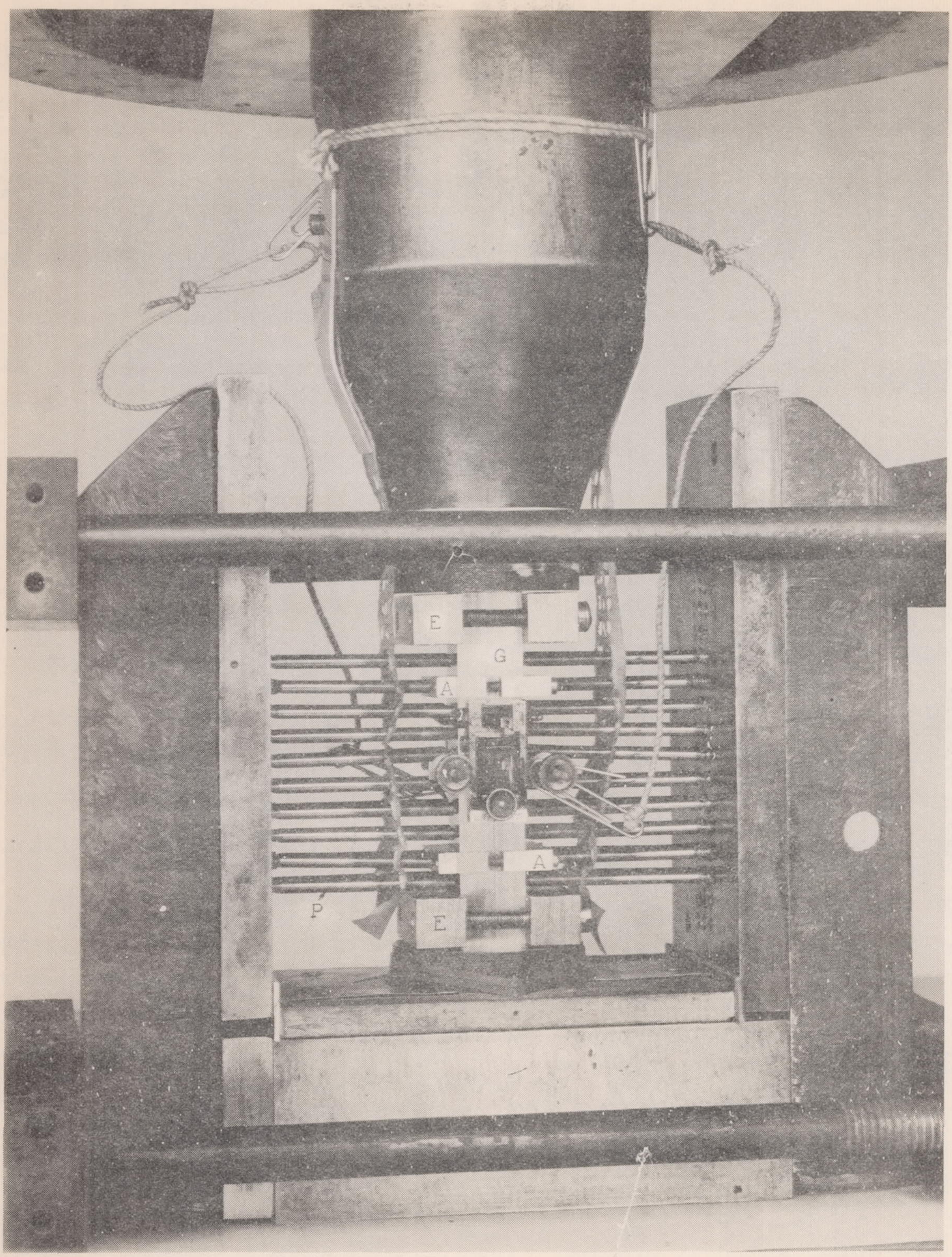

Figure 1 - Pack ready for test.

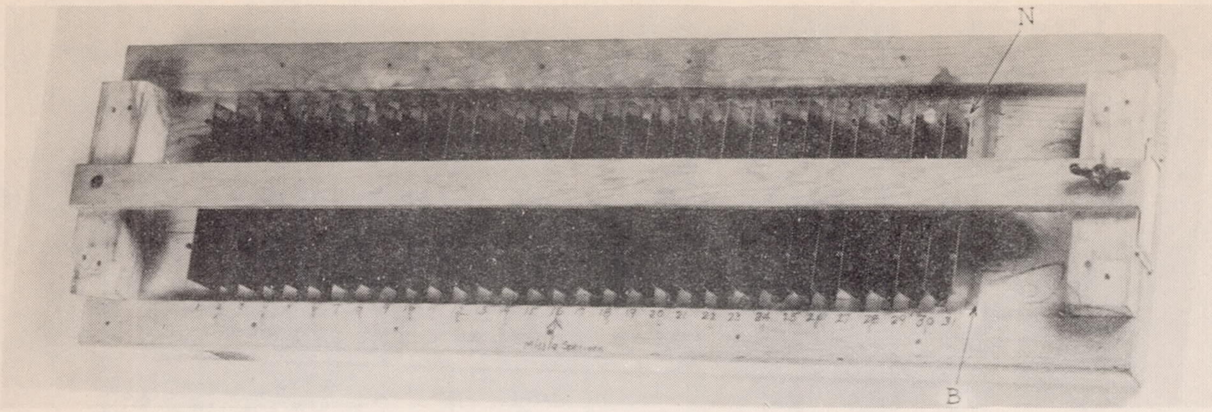

Figure 2.- Rack for specimens.

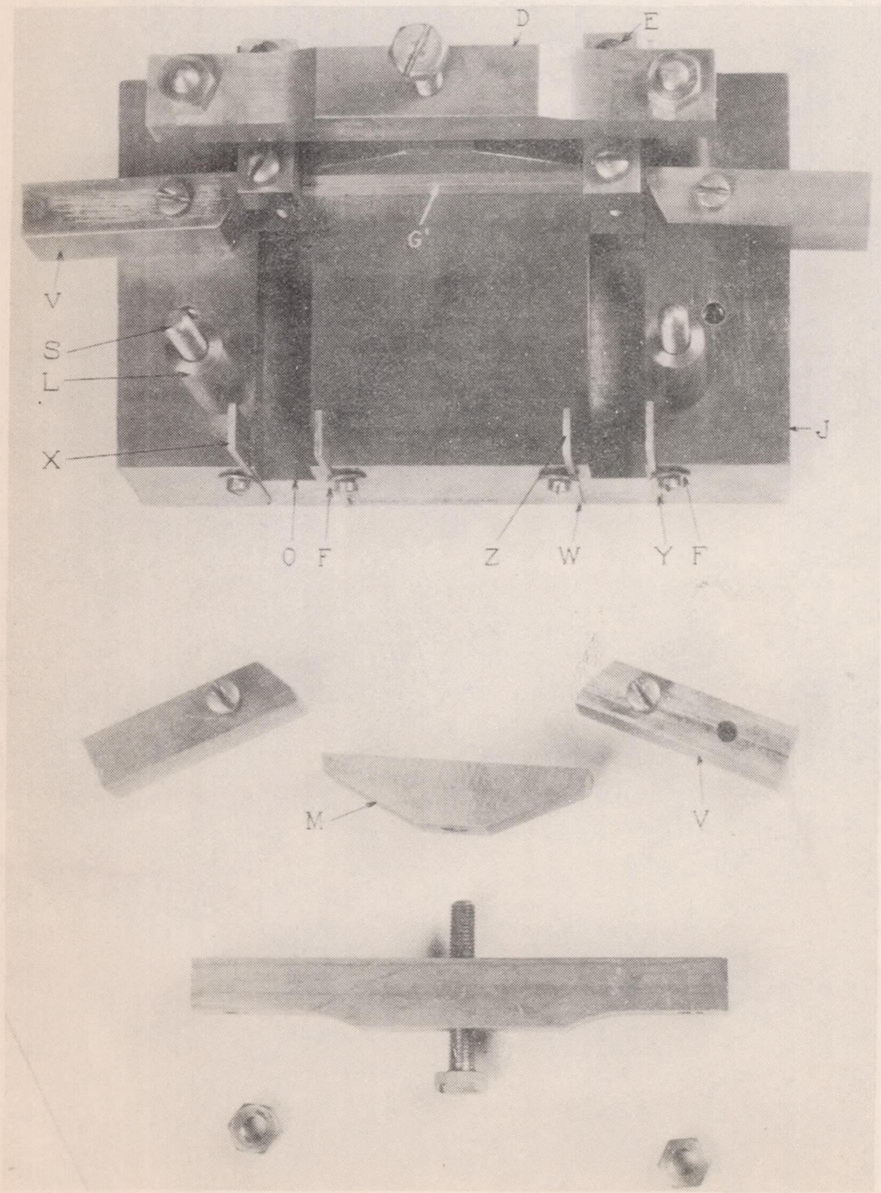

Figure 3.- Fusing jig; pack at G'.

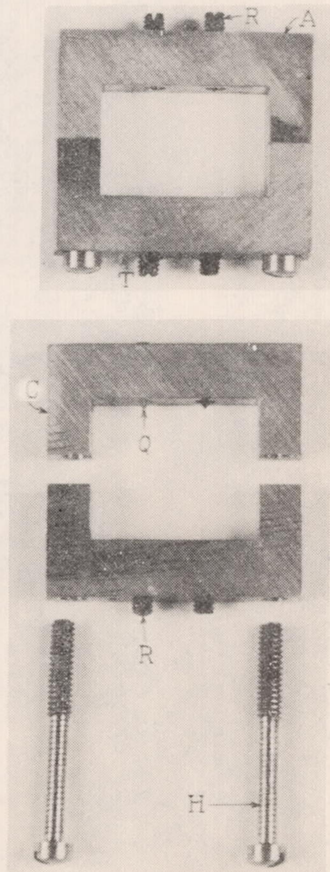

Figure 4.- Auxiliary clamps.

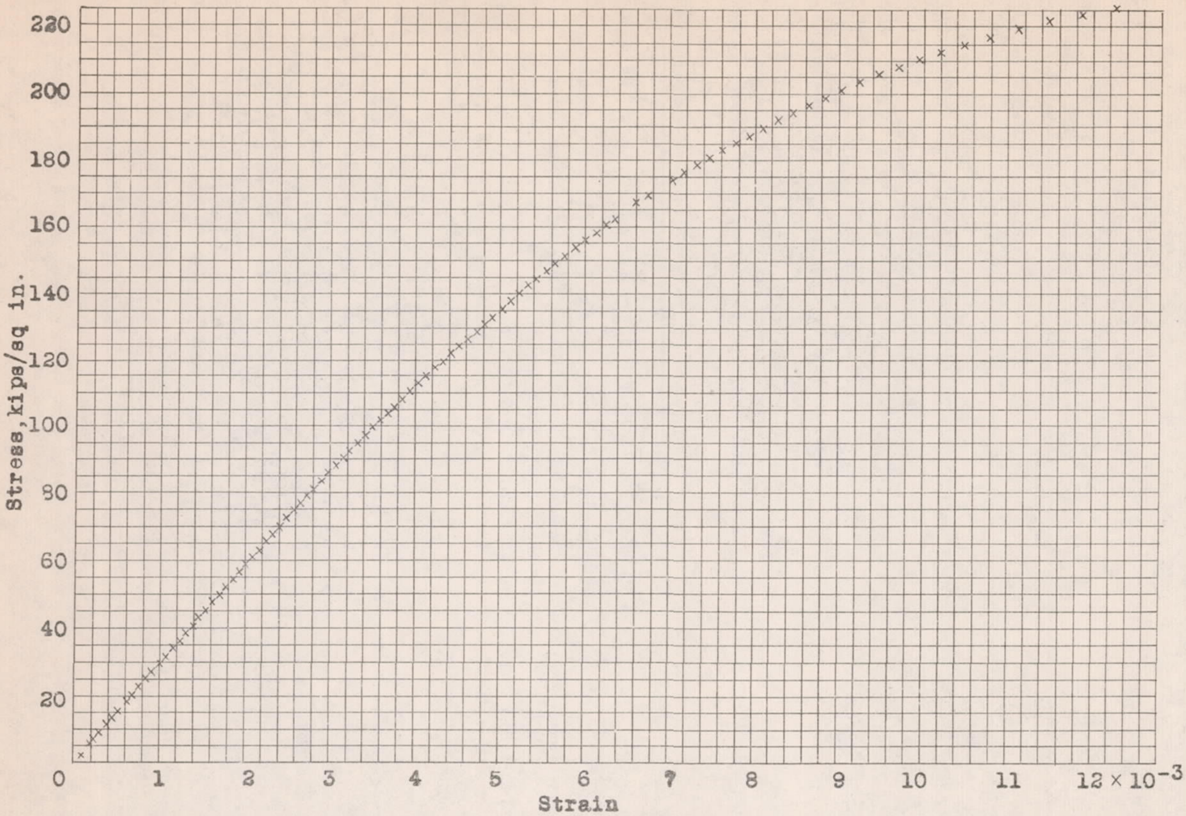

Figure 5.- Stress-strain graph for a pack of 31 specimens taken in the transverse direction from 0.02-inch-thick sheet.

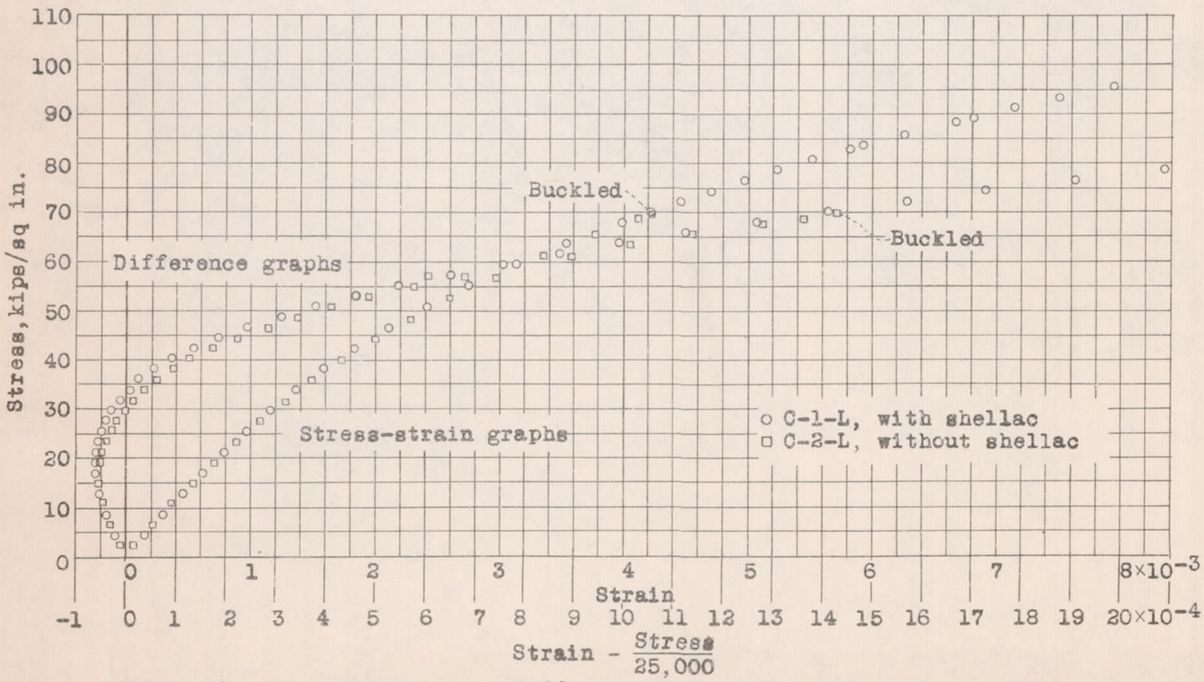

Figure 6.- Stress-strain and difference graphs for packs C1L and C2L from pack compressive tests.